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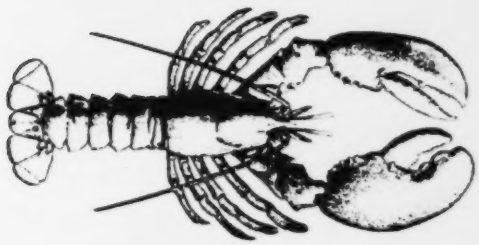
FRAMEWORK AND ASSESSMENT INDICATORS FOR LOBSTER (*HOMARUS AMERICANUS*) IN THE BAY OF FUNDY, LOBSTER FISHING AREAS (LFAs) 35, 36, AND 38



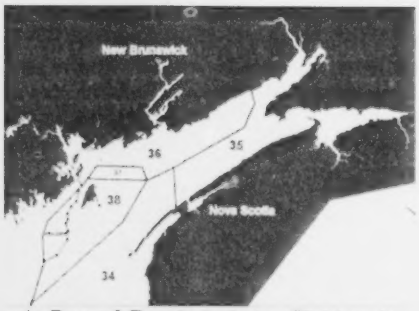


Figure 1: Bay of Fundy Lobster Fishing Areas 35, 36 & 38 and adjacent LFA 34.

Context

In 1994, the Fisheries Resource Conservation Council (FRCC) was requested by the federal fisheries Minister to review the current approaches to conservation, and recommended strategies for sustainable exploitation of all Canadian lobster stocks. In their report (FRCC, 1995), they concluded that the present fisheries were operating at excessively high exploitation rates, harvesting primarily immature animals, and not allowing for adequate egg production (estimated to be as low as one to two percent of what might be expected in an unfished population). While they accepted that lobster stocks have historically been resilient, they concluded that the risk of recruitment failure was unacceptably high and suggested that egg production be increased. A precautionary biological reference point was recommended in the form of a target level of egg production per recruits (E/R) equivalent to 5% of that of an unfished population. After consultation, the Minister decided not to increase egg production to 5% and instead to double egg per recruit in all LFA's.

In the Bay of Fundy, a 4 year management strategy (1998-2001) was developed. As a result the minimum legal size limits were increased (by 1.5 mm CL) and v-notching was introduced. The status of the lobster stocks in the Bay of Fundy was last assessed by Lawton et al. (2001). It was concluded that the fishery was experiencing record landings and that the short term outlook was for landings to remain high and over the mid-term (3-5 yr) may experience a decline. Because of high recruitment, exploitation rate could not be estimated. The potential benefits in egg production due to v-notching could not be evaluated. In 2002, new data collection and management measures were introduced. A new management measure introduced in 2003 to return culls (female lobster with only one or no claw) was subsequently removed in LFAs 36 & 38 during fall 2006 because its benefits for egg production could not be evaluated and was perceived to be of little conservation value.

The fishery presently operates on a yearly review basis. The Lobster Conservation Working Group and Scotia-Fundy Region's Lobster Conservation Strategy recommended that within each LFA, indicators be developed that are supported by a broad representation of stakeholders. The purpose of this Science Advisory Report is to evaluate the 2005-06 stock status of lobster fisheries in the Bay of Fundy, LFAs 35, 36 & 38 and recommend an assessment framework, including indicators for monitoring the health of the lobster stock, to guide future assessments.

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Canada

SUMMARY

Any changes in fishing efficiency (or "effective effort", from larger vessels, better navigation or improved fishing strategy) have not been accounted for here. Hence, any fishery dependent catch rate indicators will be biased.

- **Abundance indicators** for legal size lobster which include landings and catch rate from at-sea sampling data are primarily positive.
  - Landings in the Bay of Fundy (LFAs 35, 36 & 38) as a whole continue to be above long-term means and during the last five years have stabilized at an historical high plateau. During the 2005-06 season landings peaked at an historical high.
  - Landings in each LFA generally followed the pattern of the Bay of Fundy as a whole.
  - Fall catch rates, based on at-sea sampling, for the Bay of Fundy were higher except for a decline in the upper BOF (Alma), compared to the 1997 – 2001 period.
  - The relationship between increased effective effort and landing trends is a source of uncertainty.

- **Fishing pressure indicators** based on the 2003-06 sea-sampling data and 2004-05 landings, indicates that the stock is still fished at moderate levels with estimates for exploitation based on Length Cohort Analysis on the order of between 52 to 58%.

- **Production indicators** showed either no changes or were positive in relation to reference periods (specified below).
  - Since 1992, pre-recruit abundance (one-year prior to the fishery) based on fall at-sea sampling for the Bay of Fundy has been high. During the last five years pre-recruit abundance has been relatively stable as a whole with some decreased at two index ports (Alma and Dipper Harbour) and increases at two other index ports (Seal Cove and Victoria Beach).
  - Based on at-sea sampling and dive surveys, berried females are generally more abundant from the late 1990s to the present, compared with the 1980s and early 1990s.
  - Lobster settlement index (since 1991) based on fall diving surveys off Beaver Harbour (LFA 36), showed an historical high settlement densities pulse of recruitment in 2005 and 2006. These historically high settlement densities were also evident along the north eastern coast of Maine.

- **Ecosystem indicators** were not evaluated for the Bay of Fundy.

- Recommendations for **assessment framework indicators** are:
  - Fishery dependent indicators of abundance, such as landings and catch rate, need to be compared with changes in effort.
  - Fishery-independent indicators of abundance such as, legal sizes (moult-classes), berried females, and pre-recruits, are needed to overcome the uncertainty associated with fishery-dependent indicators.
  - Fishing pressure indicators such as trap-hauls, fishing location, vessel size, navigation, trap design and fishing strategy, are required.
  - Production indicators such as newly settled lobster indices should be expanded across the Bay of Fundy in order to improve their predictive value.

- Ecosystem indicators to estimate fishery impacts on the ecosystem with respect to by-catch of non-lobster species and potential impact of lobster fishing on the habitat requires an approach to collect and process new information.

- The recommended **assessment schedule** is every 5 years. However, annual **monitoring** of the above indicators would be used to determine if an earlier than scheduled assessment is required.

- An assessment framework for the development of indicators related to assessing, stock status, and the effects of management measures need to be developed before the next assessment.

BACKGROUND

Species Biology

The American lobster habitat extends along the Atlantic coast from North Carolina to Labrador. In Canadian waters, lobsters may be fished in deep waters (e.g., Georges Bank, Bay of Fundy (BOF)) but are generally fished close to shore in depths ranging from 1 to 30 m as in the southern Gulf of St Lawrence (SGSL).

The life history of the lobster can be divided into a benthic and planktonic phase. The planktonic phase follows the hatching of the eggs in July and August. The larvae will go through the free-swimming period that lasts from 3 to 10 weeks depending on environmental conditions, mostly temperature. The planktonic phase ends at stage IV when the larvae settle on the substrate. In the BOF most lobsters mature between 95 and 109 mm CL (8 to 10 years old). Male lobsters become sexually mature at smaller sizes and ages than females. Mating occurs between July and September. Generally, female lobsters extrude eggs one year after mating and carry the eggs, attached under the abdomen, for nearly another year.

Lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobsters' range, these movements amount to a few kilometres however, in the BOF, Gulf of Maine, the offshore regions of the Scotian Shelf and off New England, lobsters can undertake long distance migrations of 10s to 100s of kilometres.

Fishery

In the Bay of Fundy, commercial lobster fishing began in the mid-1800s and annual lobster landings in the Gulf of Maine were first recorded in 1892. Landings peaked in 1894 at 1,415 metric tons (t) and were followed by a decline, dropping to 53 t in the early 1900s. The landings remained low (198-417 t) during the 1920s until the early 1940s. Landings rose following WW II, varying between 438 and 897 t (averaging 666 t) until the mid 1980s. Beginning in 1946-47, landings began to be reported seasonally. From the 1946-47 fishing season, over the following 40 years landings remained relatively constant averaging 681 t seasonally (Fig. 2). From 1986-87 to 1993-94, landings stabilized at a higher level averaging 998 t yearly. From 1994-95 landings began to increase as part of a western Atlantic wide pattern that saw landings increased over the entire east coast of North America. The underlying cause of this increase is not known but the large scale nature of the increase suggests environmental condition may have led to improved larval and juvenile survival. In the Bay of Fundy, during the last five years, landings levelled off at an historical high plateau averaging 3701 t seasonally. During the 2005-06 season, landings peaked at an historical high of 3997 t. Landings in individual LFA's generally followed the pattern of the Bay of Fundy as a whole (Fig. 3).

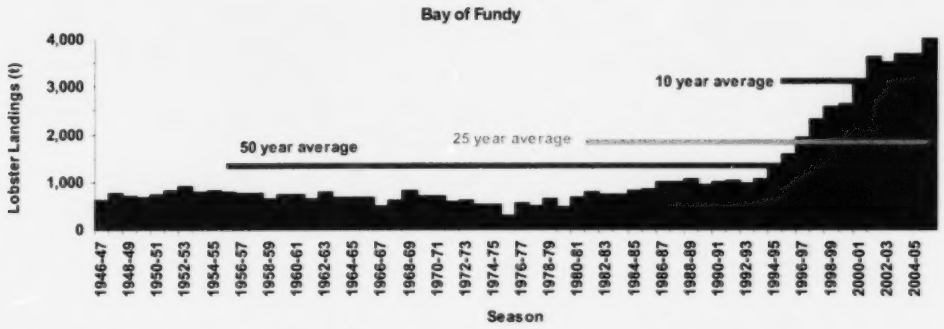

Figure 2: Landings in the Bay of Fundy showing historic means.

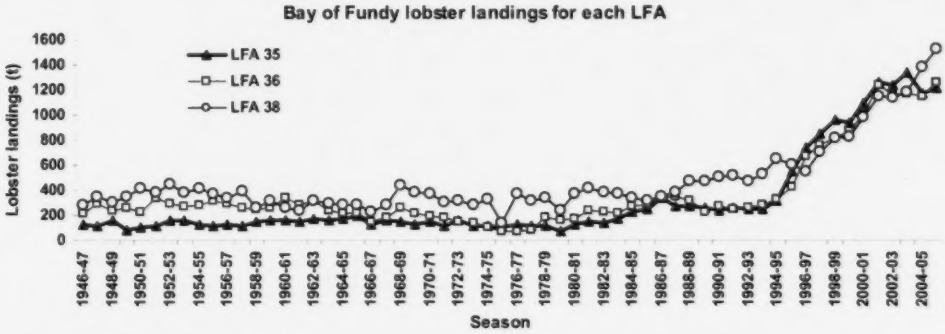

Figure 3: Bay of Fundy landings (t) by individual LFAs, 1946-1947 to 2005-2006.

In the Bay of Fundy, lobster is a valued resource shared by lobster fishers from three lobster management units referred to as Lobster Fishing Areas or LFA's (Fig. 1). These fisheries (LFA's 35, 36 & 38) are managed by input controls including a common minimum size limit of 82.5 mm carapace length (CL), prohibition on landing V-notch or berried females, limited entry, seasons and trap limits (Table 1). There are a total of 403 Category A, and 7 Category B licenses (Table 1). The number of participants, and trap limits vary among LFA's. LFA 37 is a shared area where fishermen from LFA's 36 & 38 are authorized by licence condition to fish in.

In summer 2002, a lobster fishery was opened to Canadian fishermen in a disputed area being fished by American fishermen called the Grey Zone or LFA 38B (Fig. 1). The Grey Zone, which is part of LFA 38 lobster fishing grounds during the regular fishing season, is fished by American fishermen throughout the year including the summer months when the Canadian fishing season was closed. The LFA 38B fishery is limited to a maximum of 20 LFA 38 licensed fishermen. The season is open from July to October. An arbitrary quota of 175 t and a 300 trap limit was set.

During the early part of the Bay of Fundy fishery, management regimes evolved independently in each management unit (Lawton et al. 1999). As a consequence of improvement in technology, such as hydraulic haulers, bigger and faster boats, Loran C and eventually GPS, and changes in the way that lobster fishing was conducted, in 1986, outer boundary lines were established between LFA's (Fig. 1). Presently, evidence based on information from the grid based logbook introduced in 2003, indicate that an important component of the Bay of Fundy lobster fleet have expanded their fishing effort to deeper water further from shore and from their home port, thereby exploiting most of the available lobster grounds.

Table 1. Key management measures in the Bay of Fundy.

Management measures	**Description**		
Lobster Fishing Areas (LFAs)	**LFA 35**	**LFA 36**	**LFA 38**
Fishing season	Oct. 14th to Dec. 31st April 1st to July 31st	2nd Tuesday in Nov. to Jan 14th March 31st to June 30th	2nd Tuesday in Nov. to June 30th
Number of Category A licences (Category B)[1]	92 (4)	176 (2)	135 (1)
Number of traps per Category A licence (Category B)[1]	300 (90)	300 (90)	375 (113)
One rectangular escape mechanism not more than 250 mm from the floor in the parlor section of trap (dimension in mm) or Two circular openings not more than 250 mm from the floor in the parlor section of trap (diameter in mm).	Dimension of unobstucted opening not less than 44 mm in height and 127 mm in width or Diameter of unobstucted opening not less than 57.2 mm		
Biodegradable mechanism in the parlor section of the trap	Dimension of unobstucted opening not less than 89 mm in height and 152 mm in width		
Biological measures	**Description**		
Minimum legal carapace length (mm)	82.5	82.5	82.5
Landing of egg-berring females is prohibited	Common to all LFAs		
Landing of v-notch females is prohibited	Common to all LFAs		
Landing of cull (one claw or no claw) females is prohibited	Only in LFA 35	N/A	N/A

[1]Category A represent fishermen with a full set of gear and Category B with lower trap limits

ASSESSMENT

Sources of Information

Indicators for abundance (legal sizes), fishing pressure and production (pre-recruits and spawners) were developed from data sources such as landings, logbooks, at-sea sampling, and from fisheries independent dive surveys. Abundance indicators were based on landings and catch rates from at-sea sampling. Fishing pressure indicators were based on the percentage of catch in the first molt group and exploitation estimates (Length Cohort Analysis). Production indicators were based on pre-recruit catch rate from at-sea samples of the commercial catch, on lobster settlement index and on spawners density estimates from fishery independent dive surveys and spawners catch rate from at-sea samples of the commercial catch.

To account for the fact that the Bay of Fundy is divided into three LFAs and is a large and diverse fishing area, indicators were applied either to individual LFAs and to representative ports within each LFA, or to the Bay of Fundy as a whole, based on information extrapolated from smaller units associated to "grid groups" (Fig. 4). Some grid groups were based on depth of water to give a near shore and deeper water area perspective. Others were divided based on historical lobster size differences. Indicators were also evaluated based on three fishing periods: 1) Fall – October 14th to December 31st; 2) Winter – January 1st to March 31st; and 3) Spring – April 1st to July 31st.

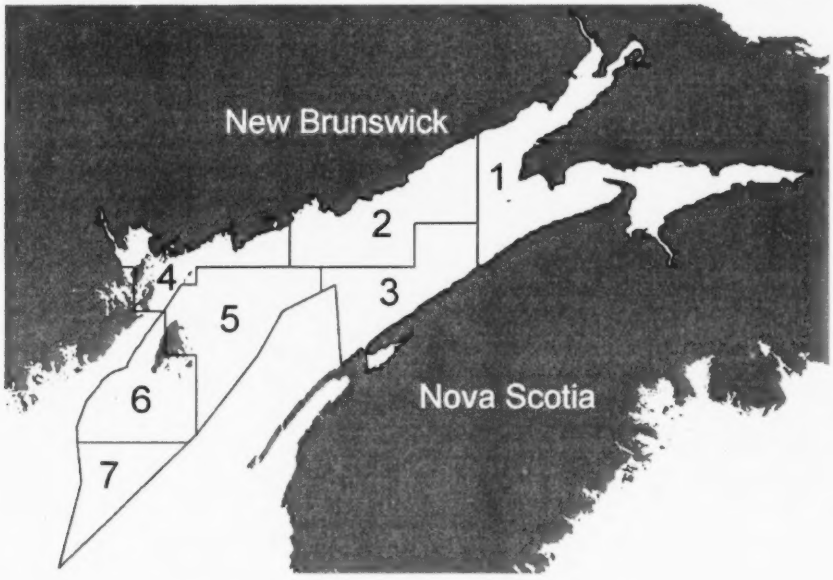

Figure 4: Grid groups from combinations of 10 minute grids in the Bay of Fundy.

Abundance (Legal Sizes)

Catch rates (in number of lobsters per trap haul (# lob/th)) based on Bay of Fundy logbooks could not be compared to any reference period due to the recent introduction of these logbooks in fall 2003. However, catch rates based on a 30 years time series of at-sea sampling during fall at four representative ports in the Bay of Fundy, were generally still higher during the last five years (2002-06) relative to the previous five years (1997-2001) and the longer term time series (Table 2). However, in the Upper Bay of Fundy (Alma) the catch rates were lower relative to the reference period (1997-01) during which the upper Bay of Fundy experienced a major recruitment pulse. The spring at sea sampling is not representative of commercial size abundance due to the higher variability in catchability and lower catch rates.

Bay of Fundy lobster landings averaged 3701 t per fishing season during the last five seasons (2001-2006) in comparison to 2500 t per season for the previous period (1996-2001) (Table 2).

Table 2. Abundance indicators of legal size lobsters by molt group and landings comparison between the recent fall at-sea sampling period (2002-06) and the previous fall at-sea sampling period (1997-2001). "+" is higher relative to the previous period, "-" is lower and "o" is no change detectable.

Catch rate of legal size by molt group from sea sampling at four representative ports	**Alma**	**Dipper Harbour**	**North Head**	**Seal Cove**
Fall (five year average # lob/th)				
1st molt (83-94 mm CL) 1997-01 vs 2002-06	-	+	+	+
2nd molt (95-109 mm CL) 1997-01 vs 2002-06	-	+	+	+
3rd molt (110 + mm CL) 1997-01 vs 2002-06	-	+	+	0
Lobster landings within each LFA	**LFA 35**	**LFA 36**	**LFA 38**	**Total BOF**
1996-2001 vs 2001-2006 fishing seasons	+	+	+	+

Fishing Pressure

The proportion of lobsters in the first molt group (83-94 mm CL) into the fishery is a coarse indicator of removal rate. A high proportion indicates that most of the catch comes from those sizes that have just become available to the fishery. Using the percentage in the first molt group as an indicator of year to year changes is problematic because this assumes that recruitment is not changing over the years, and that there is no change in catchability or targeting of specific size groups. These assumptions need to be confirmed. Thus, this indicator is only used as an indicator of the average level of exploitation over a number of years, rather than to assess year to year changes.

Using landings from the 2004-05 fishing season and at-sea sampling size data from the 2003-04 to 2005-06 fishing seasons, estimates of the proportion of lobsters in the first molt group were compared with estimates from the 1998-99 and 1999-00 seasons (Lawton et al. 2001). During the 2004-05 fishing season, the percentage of lobsters in the first molt group in the Bay of Fundy as a whole was 56%, ranging from 51% in LFA 35 to 62% in LFA 36 and 55% in LFA 38. This estimate is lower in comparison of the proportion of lobsters in the first molt group in the Bay of Fundy as a whole during the 1998-99 (66%) and the 1999-00 (65%) seasons (Table 3). The proportion of lobsters in the second molt group (95-109 mm CL) was slightly higher at 26% in 2004-05 compared to 23% and 24% in 1998-99 and 1999-00 respectively. In the third molt group (110 + mm CL) there was a higher proportion of large lobsters during the 2004-05 season (18%) compared to the 1998-99 (11%) and 1999-00 (11%) seasons.

Table 3. Fishing pressure indicators comparing the proportion of lobsters in each molt group, between the last assessment (1998-99 and 1999-00) and the present estimates (2004-05). These symbols gives the direction of the change rather than whether it is positive or negative for the fishery ("+" is higher relative to the previous period, "-" is lower and "o" is no change detectable).

1998-99 and 1999-00 vs 2004-05	LFA 35	LFA 36	LFA 38	BOF Total
% in 1st molt group (81-83 to 94 mm CL)	--	--	--	--
% in 2nd molt group (95- 109 mm CL)	+	+	+	+
% in 3rd molt group (110 + mm CL)	+	+	+	+

The relatively lower proportion (51-62%) of lobsters in the first molt group indicates that the Bay of Fundy as a whole could be less susceptible to small changes in recruitment levels than adjacent LFA 34 (Pezzack et al. 2006) where the proportion of the catch in the first molt group is high (79 to 80%). This could explain the relative stability in landings in the Bay of Fundy over the last five years.

It is difficult to determine which processes are having an impact on this observed change. The decrease in the proportion of animals in the first molt group coupled with an increase in the proportion of large animal in the second and third molt group indicates an increase in the number of large lobsters available coupled with a possible decrease in recruitment. Recent logbook information confirms an increase in effort in the deeper water mid-bay area and the targeting of larger size lobsters. Therefore the reduction in the proportion of the first molt group could be partly attributed to the targeting of sea sampling to deeper water in the mid bay areas where low numbers of lobsters in the first molt group are present and where at-sea sampling coverage was low during the previous assessment.

In the deeper water mid-bay area, there is some concern of fishing-down of the larger size lobster population, shifting more and more of the landings to the newly recruited animals and reduce the reproductive output.

The length cohort analysis (LCA) was based on the same data and the same assumptions as in the estimates for the percentage in the first molt group indicator. As such, it is again used to assess the average level of exploitation rather than year to year changes. In the present assessment, the exploitation rate was estimated to be moderate, in the range of 52-58% (Robichaud & Pezzack 2007).

Production

Production indicators such as pre-recruits, berried females abundance and of lobster settlement showed either conflicting signal or were positive in relation to reference periods. These indicators are limited, i.e. not as many indicators and less data available.

Pre-recruits (75-80 mm CL prior to 1998 and 77-82 mm CL after minimum size increase in 1998 and 1999) abundance based on the number of lobsters per trap hauls (# lob/th) from at-sea sampling of five representative ports across the Bay of Fundy continues to be high. However, off Alma (LFA 35) and Dipper Harbour (LFA 36), the average catch rates of pre-recruit for the last five falls (2002-06) have declined in comparison to the previous five falls, yet the catch rates have remained above pre 1992 levels (Table 4). In contrast, the average catch rates of pre-recruits off Seal Cove (LFA 38) were at an all time high and were much higher during the recent reference period (2002-06) in comparison to the previous period (1997-01). No change in the abundance of pre-recruits was evident in the Delap Cove (LFA 35) area and only a slight increase in the abundance of pre-recruits was detectable off Victoria Beach (LFA 35) during recent years (Table 4).

Table 4. Production indicator comparison of the average catch rates of pre-recruits between the recent fall of at-sea sampling period (2002-06) and the previous fall period (1997-2001). These symbols gives the direction of the change rather than whether it is positive or negative for the fishery ("+" is higher relative to the previous period, "-" is lower and "o" is no change detectable).

Catch rate of pre-recruits (75-80 & 77-82 mm CL) from sea sampling at five representative ports.	Alma (LFA 35)	Victoria Beach (LFA 35)	Delap Cove (LFA 35)	Dipper Harbour (LFA 36)	Seal Cove (LFA 38)
Fall (five year average # lob/th) 1997-01 vs. 2002-06	-	+	0	-	+

Berried female abundance based on at-sea sampling during the month of July in the upper Bay of Fundy (LFA 35) showed major increases during 2003 and 2004 and then a decline to historical low levels in 2006. In comparison, berried females were more abundant during the last five years than the previous five years (Table 5). They were also more abundant from the late 1990s to the present, compared with the 1980s and early 1990s. The abundance of berried female in the upper Bay of Fundy is variable and dependent largely on the migration of berried females into the area during July. Although, this indicator is variable and not sensitive to minor changes, it can still be valuable in detecting major changes in abundance.

Table 5. Production indicators comparing the average catch rates from at-sea sampling of berried females during July, between the recent reference period (2002-06) and the previous period (1997-2001). These symbols gives the direction of the change rather than whether it is positive or negative for the fishery ("+" is higher relative to the previous period, "-" is lower and "o" is no change detectable).

Catch rate of berried females from sea sampling at four representative ports in LFA 35, during July.	Alma	Advocate	Delap Cove	Victoria Beach
Five year average # lob/th 1997-01 vs. 2002-06	+	+	+	+

Berried female abundance indicators based on diving surveys off Flagg Cove, Grand Manan (LFA 38) has showed a sharp decline in 2005, followed by an increase in 2006 to level similar to the late 1990's (Fig. 5). In general, they were more abundant from the late 1990s to the present, compared with the 1980s and early 1990s. However, this set of data comes from one small location only and it is difficult to presume that the abundance of berried females in Flagg Cove represents the abundance for the whole of the Bay of Fundy. This indicator of abundance, based on diving surveys, is presumed to better reflect the abundance of berried females in the population compared to trap derived estimate. Sources of bias such as catchability and soak days, associated with trapping do not impact these dive survey data.

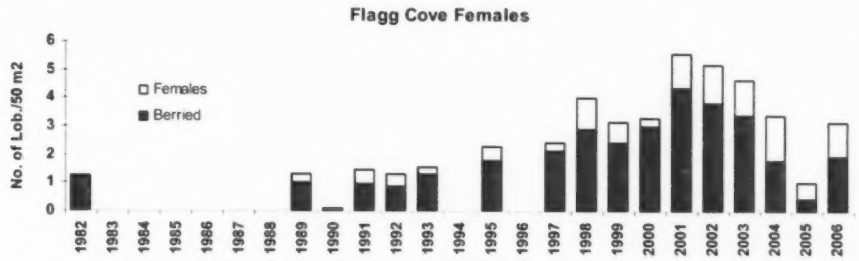

Figure 5. Density of females (# females/50 m^2) during September diving surveys in Flagg Cove, Grand Manan (LFA 38) from 1982 to 2006.

Lobster settlement densities based on diving surveys off Beaver Harbour (LFA 36) showed a pulse of recruitment during 2005 (Fig. 6). In 2005, the area experience a recruitment pulse (2.0 lobsters/.25m2) equal to a five folds increase above a 13 year average, followed by a higher than average settlement density (1.0 lobster/.25m2) in 2006. Since 2003, settlement densities have been above average.

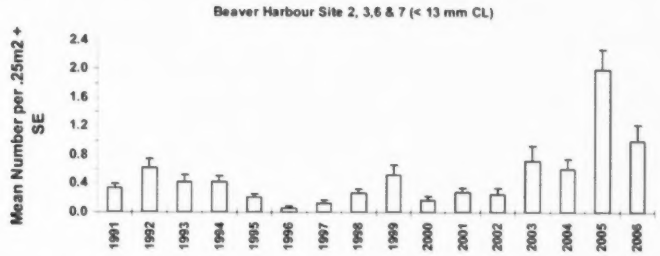

Figure 6. Annual settlement densities (# lob/0.25 m^2) of lobsters (< 13 mm CL) captured during diving surveys during Oct. /Nov. off Beaver Harbour (LFA 36), from 1991 to 2006.

These settlement densities are nearly equal or higher in comparison to study sites along the New England States. The remarkable feature of the 2005 survey was the pulse of high settlement in north eastern Maine and New Brunswick (Beaver Harbour). North eastern Maine, which historically has received a relatively poor supply of settlers, experience higher densities that are more comparable to western Maine. This pulse of settlement in north eastern Maine and New Brunswick may bode well for recruitment to the fishery in the future. However, the settlement index has not yet been proven to be of predictive value for trends in the abundance of lobsters in the Bay of Fundy and the coast of Maine.

Sources of Uncertainty

Fishing pressure indicators (# of traps, fishing days) could not be related to any long term time series due to the fact that the new Bay of Fundy commercial fishing logs were only introduced during fall 2003 and that the only season during which these logs were fully completed was in 2004-05.

Landings are a function of abundance, the level of fishing effort (trap hauls, soak-days, timing of effort and fishing strategy) and catchability. Catchability in turn is affected by environmental conditions, gear efficiency including trap design, bait, and other factors. Changes in any of these can affect landings and catch rates. Thus landings do not necessarily reflect the changes in abundance.

Changes in fishing efficiency (or "effective effort") have not been accounted for here. If fishing efficiency has increased in the last five years due to larger vessels, better navigation or improved fishing strategy, then the catch rate index may inflate the perception of abundance in recent years.

There are anecdotal indications that larger sizes of lobsters have been targeted in recent years. This has not been quantified. An approach is needed to account for changes in fishing strategy and efficiency.

Indicators of mature females assume a size-at-maturity relationship that has not been re-evaluated since the early 1980s.

CONCLUSIONS AND ADVICE

Framework

Recommended indicators depend upon Bay of Fundy logbooks, at-sea sampling, diving base surveys and out of season trapping data.

Data Sources: Existing indicators based on Bay of Fundy logbooks should be continued and improved. Current fishing logs are essential and provide the basis for current indicators of abundance and fishing pressure. High participation rates, accurate records and timely data entry are required. The FSRS traps which are used in LFA 34 to provide pre-recruit indicator should be expanded into the Bay of Fundy. At sea samples should be maintained, expanded and focused on specific times and areas where other data sources are lacking. Use of fishermen based measurements from commercial traps should be explored. Data from scallop, groundfish and ITQ surveys should be developed. Indicators based on diving surveys should be maintained and even expanded into new areas. New fishery-independent surveys should be considered.

Abundance Indicators: Landings are the first level of abundance indicator and although they may not always track abundance changes, landings will continue to be monitored for a variety of reasons. The log-linear model of catch rate from logbooks used in the LFA 34 assessment is a good method to track commercial catch rate and should be used in future Bay of Fundy assessment and updated on an annual basis. To better interpret catch rate changes, indicators of fishing efficiency such as boats, navigation, and traps is needed.

Fishery-independent indicators of abundance are needed to overcome the uncertainty associated with indicators based on commercial fishing where efficiency and strategy change. Fishery-independent indicators of abundance could be expanded from existing diver based surveys or developed from existing surveys that catch lobsters in towed gear, from standardized trap surveys and possibly from underwater video surveys.

Fishing Pressure Indicators: Indicators such as trap hauls, effort distribution by grids and days fished, could not be compared to any referenced period due to the recent introduction of the Bay of Fundy grid based logbooks during fall 2003. Due to the short time series no indicator summary table could be produced. However, in the coming years, the grid based logbook, should provide an important source of information that will be useful as indicators of change in fishing activity and the distribution of effort.

Percentage of the catch in molt group one and "Length Cohort Analysis" appears to be limited to evaluating average exploitation over a number of years. However it can be applied in all areas.

Additional indicators of fishing effort (vessel size, navigation, trap design fishing strategy, etc.) are required because the Bay of Fundy lobster fishery is largely effort-controlled and the "quality" of effort is not being tracked effectively. The effect of soak time on our perception of effort should be evaluated. The distribution of fishing effort is extremely important and spatial distribution indicators of fishing effort should be developed from the location data provided in fishing logs.

Production Indicators: Fishery-dependent production indicators such as the recording of berried females during commercial fishing in some areas may form the basis for one indicator. Catch rates of berried females in at sea samples are low but the overall size frequency of females could provide a proxy estimate. Indicators of pre-recruits using the FSRS type trapping protocol are needed for the Bay of Fundy. Another possibility is to collect recruitment type data from commercial traps.

Fishery-independent production indicators such as mature or berried females, pre-recruits, and newly settled lobsters are needed are needed to overcome the uncertainty associated with fishery-dependent indicators. Indicators for mature and berried females are required to estimate reproductive output directly and to track this important component of the population. Trap sampling of berried females outside of the fishing season may be needed. Settlement indicators are needed for juveniles that are more than three years from reaching fishable sizes (less than approximately 50 mm CL). Such an indicator can not be obtained by the commercial fishery and would give advance warning of downturns in recruitment and could be obtained by out-of-season sampling.

Ecosystem Indicators: Indicators to estimate fishery impacts on the ecosystem with respect to by-catch of non-lobster species and potential impact of lobster fishing on the habitat requires an approach to collect and process this information. Long-term temperature monitoring

throughout the year is essential to understand potential changes in catchability and molt timing. However it will be sometime before indicators such as ocean productivity, predators and prey will be operational.

Assessment Schedule: The recommended assessment schedule is every 5 years. However, annual monitoring of the above indicators would be used to determine if an earlier than scheduled assessment is required.

General Comments: Recognizing that progress has been made, with respect to examining current indicators, data limitations, and interpretation of trends, there was insufficient opportunity to fully address all stated objectives of the review.

These are:

- explore the best suite of indicators to determine the status of the resource and supporting habitat,
- estimate fishery impacts on the ecosystem,
- develop issues relevant to improvement in management,
- develop a schedule of assessment including guidelines for monitoring of indicators to trigger an earlier than scheduled assessment,
- guidelines on indicators and levels that would trigger an earlier than scheduled assessment,

These objectives should be addressed prior to the next assessment.

Assessment

Lobsters in the Bay of Fundy as a whole continue to be in high abundance with landings well above long-term means and levelling off at an historical high plateau during the last five years. Current fishing pressure could not be compared to historical levels. This is a conservation concern regarding additional pressure on lobsters in the mid bay area in deeper water which have historically supported larger sizes and potentially important brood stock. This movement of effort from the near shore should be monitored and its potential effect evaluated.

The Bay of Fundy lobster fishery continues to have moderate exploitation rates, in the range of 52-58% (Robichaud and Pezzack 2007) and to be less dependent on new recruits making the fishery less susceptible to small changes in the levels of recruitment. Indicators of pre-recruits suggest recruitment continues to be high. However, in the upper Bay of Fundy (LFA 35) recruitment has trended downwards in the last two to three years. This indicator should be followed closely.

The cause of the historical stability of landings in the Bay of Fundy, the wide spread recruitment pulse in the early 1990s and the increase in landings since the mid 1990s are not well understood. The long term impact of changing fishing patterns over the last 20 years, notably the expansion to areas previously unfished needs to be monitored.

SOURCES OF INFORMATION

FRCC, 1995. A conservation framework for Atlantic lobster: Report to the Minister of Fisheries and Oceans: 57.

Lawton, P., D.A. Robichaud, D.S. Pezzack, M.B. Strong, and D.R. Duggan. 1999. The American lobster, *Homarus americanus*, fishery in the Bay of Fundy (Lobster Fishing Areas 35, 36 & 38). DFO Can. Sci. Advis. Sec. Res. Doc. 1999/031: 58p.

Lawton, P., D.A. Robichaud, M.B. Strong, D.S. Pezzack, and C.F. Frail. 2001. Spatial and temporal trends in the American lobster, *Homarus americanus*, fishery in the Bay of Fundy (Lobster Fishing Areas 35, 36, and 38). DFO Can. Sci. Advis. Sec. Res. Doc. 2001/094:70p.

Pezzack, D.S., C.M. Frail, P. Lawton, D.A. Robichaud, and M.B. Strong. 2001. Update on Stock Status of American Lobster, *Homarus americanus*, Lobster Fishing Area 34. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/156: 66p.

Pezzack, D.S., J. Tremblay, R. Claytor, C.M. Frail, and S. Smith. 2006. Stock status and indicators for the lobster fishery in Lobster Fishing Area 34. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/010: 141p.

Pezzack, D.S., P. Lawton, I.M. Gutt, D.R. Duggan, D.A. Robichaud, and M.B. Strong. 1999. The American Lobster, *Homarus americanus*, fishery off of South-western Nova Scotia (Lobster Fishing Areas 34). Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 99/32: 50p.

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